4

Executive Summary

Urban, Agricultural, and Environmental Water Use

This chapter describes present and forecasted urban, agricultural, and environmental water use. The chapter is organized into three major sections, one for each category of water use.

Water use information is presented at the hydrologic region level of detail under normalized hydrologic conditions. Forecasted 2020-level urban and agricultural water use have not changed greatly since publication of Bulletin 160-93. Forecasted urban water use depends heavily on population forecasts. Although the Department of Finance has updated its California population projections since the last Bulletin, U.S. census data are an important foundation for the projections, and a new census will not be performed until 2000. The Department's forecasts of agricultural water use change relatively slowly in the short-term, because the corresponding changes in forecasted agricultural acreage are a small percentage of the State's total irrigated acreage. Changes in base year and forecasted environmental water use from the last Bulletin reflect implementation of SWRCB's Order WR 95-6 for the Bay-Delta.

Nursery products are California's third largest farm product in gross value. The nursery industry is affected by the availability of both agricultural and urban water supplies.

Urban Water Use

Forecasts of future urban water use for the Bulletin are based on population information and per capita water use estimates. Factors influencing per capita water use include expected demand reduction due to implemen-

-tation of water conservation programs. The Department has modeled effects of conservation measures and socioeconomic changes on per capita use in 20 major water service areas to estimate future changes in per capita use by hydrologic region. An urban water agency making estimates for its own service area would be able to incorporate more complexity in its forecasting, because the scope of its effort is narrow. For this reason, and because DOF population projections seldom exactly match population projections prepared by cities and counties, the Bulletin's water use forecasts are expected to be representative of, rather than identical to, those of local water agencies.

Population Growth

Data about California's population—its geographic distribution and projections of future populations and their distribution—come from several sources. The Department works with base year and projected year population information developed by DOF for each county in the State. The decadal census is a major benchmark for population projections. DOF works from census data to calculate the State's population in noncensus years, and to project future populations. Figure ES4-1 shows DOF's projected growth rates by county for year 2020. (State policy requires that all State agencies use DOF population projections for planning, funding, and policymaking activities.)

Population projections used in Bulletin 160-98 are based on DOF's *Interim County Population Projections (April 1997)*. Table ES4-1 shows the 1995 through 2020 population figures for Bulletin 160-98 by hydrologic region.

TABLE ES4-1
California Population by Hydrologic Region (in thousands)

Region	*1995*	*2020*
North Coast	606	835
San Francisco Bay	5,780	7,025
Central Coast	1,347	1,946
South Coast	17,299	24,327
Sacramento River	2,372	3,813
San Joaquin River	1,592	3,025
Tulare Lake	1,738	3,296
North Lahontan	84	125
South Lahontan	713	2,019
Colorado River	533	1,096
Total (rounded)	**32,060**	**47,510**

DOF periodically updates its population forecasts to respond to changing conditions. Its 2020 population forecast used for Bulletin 160-93 was 1.4 million higher than the 2020 forecast used in Bulletin 160-98. The latter forecast incorporated the effects of the recession of the early 1990s. Small fluctuations in the forecast do not obscure the overall trend—an increase in population on the order of 50 percent.

The Department apportioned county population data to Bulletin 160 study areas based on watershed or water district boundaries. Factors considered in distributing the data to Bulletin 160 study areas included population projections prepared by cities, counties, and local councils of governments, which typically incorporate expected future development from city and county general plans. The local agency projections indicate which areas within a county are expected to experience growth, and provide guidance in allocating DOF's projection for an entire county into smaller Bulletin 160 study areas.

Factors Affecting Urban Per Capita Water Use

Urban per capita water use includes residential, commercial, industrial, and institutional uses of water. Each of these categories can be examined at a greater level of detail. Residential water use, for example, includes interior and exterior (e.g., landscaping) water use. Forecasts of urban water use for an individual community may be separated into components and forecasted individually. It is not possible to use this level of detail for each community in the State in Bulletin 160-98. Bulletin 160-98 modeled components of urban use for representative urban water agencies in each of the State's ten hydrologic regions and extrapolated those results to the remainder of each hydrologic region.

Demand reduction achieved by implementing water conservation measures is important in forecasting per capita water use. Bulletin 160-98 incorporates demand reductions from implementation of urban best management practices contained in the 1991 *Memorandum of Understanding Regarding Urban Water Conservation in California*. Bulletin 160-98 assumes implementation of the urban MOU's BMPs by 2020, resulting in a demand reduction of about 1.5 maf over the year 2020 demand forecast without BMP implementation.

The relationship of water pricing to water consumption, and the role of pricing in achieving water conservation, has been a subject of discussion in recent years. Elected board members of public water

FIGURE ES4-1.

Projected Growth Rates by County, 1995-2020

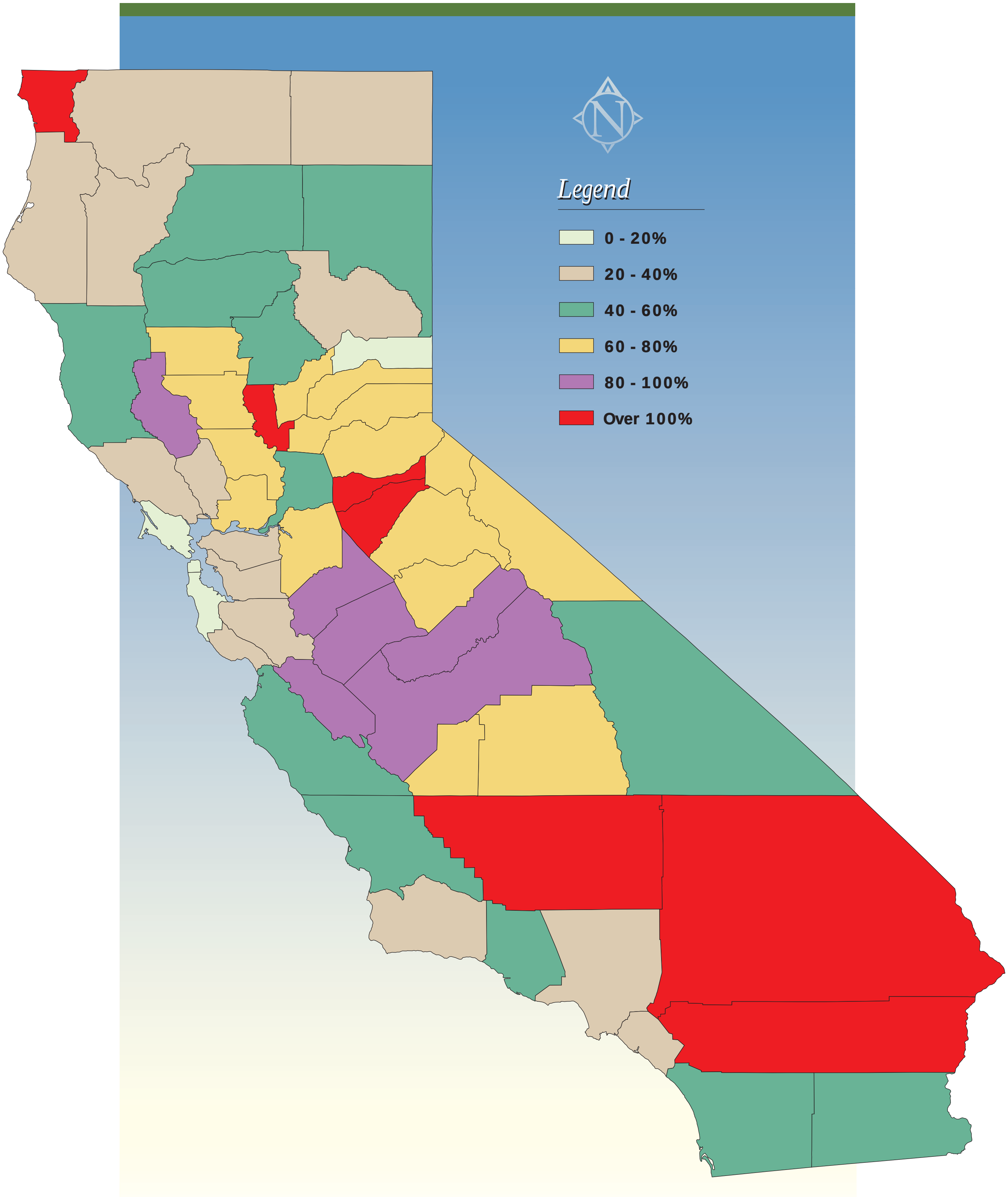


TABLE ES4-2

Effects of Conservation on Per Capita Water Use[a] by Hydrologic Region (gallons per capita per day)

Region	*1995*	*2020*	
		without conservation	*with conservation*
North Coast	249	236	215
San Francisco Bay	192	188	166
Central Coast	179	188	166
South Coast	208	219	191
Sacramento River	286	286	264
San Joaquin River	310	307	274
Tulare Lake	298	302	268
North Lahontan	411	390	356
South Lahontan	282	294	268
Colorado River	564	626	535
Statewide	**229**	**243**	**215**

[a] Includes residential, commercial, industrial, and landscape use supplied by public water systems and self-produced surface and groundwater. Does not include recreational use, energy production use, and losses from major conveyance facilities. These are normalized data.

agencies ultimately have the responsibility for balancing desires to achieve demand reduction through water pricing with desires to provide affordable water rates to consumers. Urban water rates in California vary widely and are affected by factors such as geographic location, source of supply, and type of water treatment provided. Water rates are set by local agencies to recover costs of providing water service, and are highly site-specific. According to several price elasticity studies for urban water use, residential water demand is usually inelastic, i.e., water users were relatively insensitive to changes in price for the price ranges evaluated. Water price currently plays a small role in relation to other factors affecting water use—public education, plumbing retrofit programs, etc.

High efficiency horizontal axis washing machines (front loading washers) are being used in commercial applications, but are just becoming available for home use. A check of large appliance dealers in 1998 showed that two brands of horizontal axis washers are commonly in stock, at prices ranging from $700 to $1,100. Comparable standard washers cost from $100 to $600 less. Some utilities are offering their customers rebates on the order of $100 to $150 for purchasing the horizontal axis machines.

Urban Water Use Forecasting

The Department forecasted change in per capita water use by 2020 in each hydrologic region to estimate 2020 urban applied water by hydrologic region. Variables included changes in population, income, economic activity, water price, and conservation measures (implementation of urban BMPs and changes to State and federal plumbing fixture standards). The general forecasting procedure was to determine 1995 base per capita water use, estimate the effects of conservation measures and socioeconomic change on future use for 20 major representative water service areas in California, and calculate 2020 base per capita water use by hydrologic region from the results of service area forecasts. (See Table ES4-2.)

Summary of Urban Water Use

Table ES4-3 summarizes Bulletin 160-98 urban applied water use by hydrologic region. Statewide urban use at the 1995 base level is 8.8 maf in average water years and 9.0 maf in drought years. (Drought year demands are slightly higher because less precipitation is available to meet exterior urban water uses, such as landscape watering.) Projected 2020 use increases to 12.0 maf in average years and 12.4 maf in drought years. Full implementation of urban BMPs is estimated to result in demand reduction of 1.5 maf in average year water use by 2020. Without implementation of urban BMPs, average year use would have increased to 13.5 maf.

As indicated in the Table ES4-3, the South Coast and San Francisco Bay Hydrologic Regions together amount to over half of the State's total urban water use. The table also illustrates that precipitation plays a small role in meeting urban outdoor water needs (landscape water needs) in arid regions such as the Tulare Lake, South Lahontan, and Colorado River Regions.

Agricultural Water Use

The Department's estimates of agricultural water use are derived by multiplying water use requirements for different crop types by their corresponding statewide irrigated acreage, and summing the results to obtain a total for irrigated crops in the State. This section begins by covering crop water use requirements. A description of the process for estimating future irrigated acreage, and factors affecting acreage forecasts, follows. Forecasted 2020 agricultural water demands are summarized at the end of the section.

Crop Water Use

The water requirement of a crop is directly related to the water lost through evapotranspiration. The amount of water that can be consumed through ET depends in the short term on local weather and in the long term on climatic conditions. Energy from solar radiation is the primary factor that determines the rate of crop ET. Also important are humidity, temperature, wind, stage of crop growth, and the size and aerodynamic roughness of the crop canopy. Irrigation frequency affects ET after planting and during early growth, because evaporation increases when the soil surface is wet and is exposed to sunlight. Growing season ET varies significantly among crop types, depending primarily on how long the crop actively grows.

Direct measurement of crop ET requires costly investments in time and in sophisticated equipment. There are more than 9 million acres of irrigated crop land in California, encompassing a wide range of climate, soils, and crops. Even where annual ET for two areas is similar, monthly totals may differ. For example, average annual ET for Central Coast interior valleys is similar to that in the Central Valley. Central Valley ET is lower than that in coastal valleys during the winter fog season, and higher during hot summer weather. Obtaining actual measurements for every combination of environmental variables would be prohibitively difficult and expensive. A more practical approach is to estimate ET using methods based on correlation of measured ET with observed evaporation, temperature, and other climatologic conditions. Such methods can

TABLE ES4-3

Applied Urban Water Use by Hydrologic Region (taf)

	1995		*2020*	
Region	***Average***	***Drought***	***Average***	***Drought***
North Coast	169	177	201	212
San Francisco Bay	1,255	1,358	1,317	1,428
Central Coast	286	294	379	391
South Coast	4,340	4,382	5,519	5,612
Sacramento River	766	830	1,139	1,236
San Joaquin River	574	583	954	970
Tulare Lake	690	690	1,099	1,099
North Lahontan	39	40	50	51
South Lahontan	238	238	619	619
Colorado River	418	418	740	740
Total (rounded)	**8,770**	**9,010**	**12,020**	**12,360**

be used to transfer the results of measured ET to other areas with similar climates.

The Department uses the ET/evaporation correlation method to estimate growing season ET. Concurrent with field measurement of ET rates, the Department developed a network of agroclimate stations to determine the relationship between measured ET rates and pan evaporation. Data from agroclimatic studies show that water evaporation from a standard water surface (the Department uses the U.S. Weather Bureau Class A evaporation pan) closely correlates to crop evapotranspiration. The ET/evaporation method estimates crop water use to within ± 10 percent of measured seasonal ET.

Crop coefficients are applied to pan evaporation data to estimate evapotranspiration rates for specific crops. (Crop coefficients vary by crop, stage of crop growth, planting and harvest dates, and growing season duration.) The resulting data, combined with information on effective rainfall and water use efficiency, form the basis for calculating ETAW and applied water use. Crop applied water use includes the irrigation water required to meet crop ETAW and cultural water requirements.

The amount of water applied to a given field for crop production is influenced by considerations such as crop water requirements, soil characteristics, the ability of an irrigation system to distribute water uniformly on a given field, and irrigation management practices. In addition to ET, other crop water requirements can include water needed to leach soluble salts below the crop root zone, water that must be applied for frost protection or cooling, and water for seed germination. The amount required for these uses depends upon the crop, irrigation water quality, and weather conditions.

Part of a crop's water requirements can be met by rainfall. The amount of rainfall beneficially used for crop production is called effective rainfall. Effective rainfall is stored in the soil and is available to satisfy crop evapotranspiration or to offset water needed for special cultural practices such as leaching of salts. Irrigation provides the remainder of the crop water requirement. Irrigation efficiency influences the amount of applied water needed, since a portion of each irrigation goes to system leaks and deep percolation of irrigation water below the crop root zone.

The Bulletin's 1995 base applied agricultural water use values were computed from normalized data to account for variation in annual weather patterns and water supply. Normalizing entails applying crop coefficients to long-term average evaporative demand data. Actual applied crop water use during 1995 was less than the Bulletin 160-98 base in many areas due to wet hydrologic conditions that increased effective rainfall, thus decreasing crop ETAW. Likewise, applied water use during a dry year (assuming no constraints on water supplies) would likely exceed the base due to less than average effective rainfall with an attendant increase in crop ETAW.

Bulletin 160-98 quantifies agricultural water conservation based on assumed statewide implementation of the 1996 agricultural MOU. This conservation is expected to reduce agricultural applied water demands by about 800 taf annually by 2020.

Quantifying Base Year Irrigated Acreage

Forecasts of agricultural acreage start with land use data that characterize existing crop acreage. The Department has performed land use surveys since the 1950s to quantify acreage of irrigated land and corresponding crop types, and currently maps irrigated acreage in six to seven counties per year. The base data for land use surveys are obtained from aerial photography or satellite imagery, which is superimposed on a cartographic base. Site visits are used to identify or verify crop types growing in the fields. From this information, maps showing locations and acreage of crop types are developed.

The Department's land use surveys focus on quantifying irrigated agricultural acreage. Although fields of dry-farmed crops are mapped in the land use surveys, their acreage is not tabulated for calculating water use. In certain areas of the State, climate and market conditions are favorable for producing multiple crops per year on the same field (for example, winter vegetables followed by a summer field crop). In these cases, annual irrigated acreage is counted as the sum of the acreage of the individual crop types. In the years between county land use surveys, the Department estimates crop types and acreage using data collected from county agricultural commissioners, local water agencies, University of California Cooperative Extension Programs, and the California Department of Food and Agriculture.

The starting point for determining Bulletin 160-98 1995 base acreage was normalized 1990 irrigated acreage from Bulletin 160-93. Changes in crop acreage between 1990 and 1995 were evaluated to determine if they were due to short-term causes (e.g., drought or abnormal spring rainfall), or if there was an actual change in cropping patterns. Base year acreage was normalized to represent the acreage that would most likely occur in the absence of weather and market related abnormalities.

Crop acreage by region for the normalized 1995 base is presented in Table ES4-4. The 1995 base irrigated land acreage is about 9.1 million acres, which, when multiple cropped areas are tabulated, becomes a base irrigated cropped acreage of about 9.5 million acres.

Forecasting Future Irrigated Acreage

The Department's 2020 irrigated acreage forecast was derived from staff research, a crop market outlook study, and results from the Central Valley Production Model. As with any forecast of future conditions, there are uncertainties associated with each of these approaches. The Department's integration of the results from three independent approaches is intended to represent a best estimate of future acreage, absent major changes from present conditions. It is important to emphasize that many factors affecting future cropped acreage are based on national (federal Farm Bill programs) or international (world export markets) circumstances. California agricultural products compete with products from other regions in the global economy, and are affected by trade policies and market conditions that reach far beyond the State's boundaries.

The Federal Agriculture Improvement and Reform Act of 1996, for example, affects agricultural markets nationwide, by changing federal price supports for specified agricultural commodities. Under the terms of that act, federal payments to growers will be reduced by 2002, and prior farm bill provisions that required growers to reduce planted acreage of regulated commodities are no longer in force. (Commodities with significant federal price support include wheat, feed grains, rice, cotton, dairy products, sugar, and peanuts.) The overall impact of the act to California, however, may be less than its impact to states whose agriculture is less diversified and who are less active in export markets. In 1994, for example, federal farm bill production payments to California growers represented about one percent of California's agricultural revenue. The potential impacts of FAIRA to California's agricultural market are considered in Bulletin 160-98 by the crop market outlook study.

Intrastate factors considered in making acreage forecasts included urban encroachment onto agricultural land and land retirement due to drainage problems. Urbanization on lands presently used for irrigated agriculture is a significant consideration in the South Coast Region and in the San Joaquin Valley, based on projected patterns of population growth. DOF 2020 population forecasts, along with information gathered from local agency land use plans, were used to identify irrigated lands most likely to be affected by urbanization. Local water agencies and county farm advisors were interviewed to assess their perspective on land use changes affecting agricultural acreage. For example, urbanization may eliminate irrigated acreage in one area, but shift agricultural development onto lands presently used as non-irrigated pasture. Soil types and landforms are important constraints in agricultural land development. If urbanization occurs on prime Central Valley farmland, some agricultural production may be able to shift to poorer quality soils on hilly lands adjoining the valley floor. A consequent shift in crop types and irrigation practices would likely result—for example, from furrow-irrigated row crops to vineyards on drip irrigation.

The Department's crop market outlook, a form of Delphi analysis, was developed using information and expert opinions gathered from interviews with more than 130 University of California farm advisors, agricultural bankers, commodity marketing specialists,

Factors that influence the conversion of irrigated lands to urban use include the lands' proximity to existing urban areas and transportation corridors, and local agency land use planning and zoning policies.

TABLE ES4-4

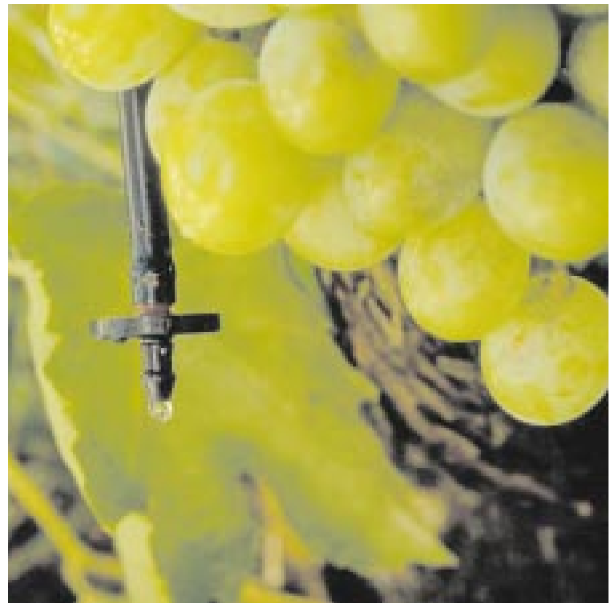
California Crop and Irrigated Acreage by Hydrologic Region, 1995 Level (thousands of acres)

Irrigated Crop	*NC*	*SF*	*CC*	*SC*	*SR*	*SJ*	*TL*	*NL*	*SL*	*CR*	*Total*
Grain	72	2	26	11	270	180	260	7	2	70	900
Rice	0	0	0	0	494	22	0	1	0	0	517
Cotton	0	0	0	0	9	185	1,026	0	0	24	1,244
Sugar beets	6	0	3	0	54	47	30	0	0	38	178
Corn	1	1	3	4	92	212	116	0	0	9	438
Other field	3	1	16	4	155	120	97	0	1	70	467
Alfalfa	53	0	21	10	149	231	296	44	34	256	1,094
Pasture	122	5	18	20	352	199	49	107	18	43	933
Tomatoes	0	0	10	7	138	82	111	0	0	9	357
Other truck	23	11	382	87	56	130	194	2	3	172	1,060
Almond/pistachios	0	0	0	0	106	251	177	0	0	0	534
Other deciduous	7	6	18	3	219	154	191	0	3	1	602
Subtropical	0	0	19	161	28	8	202	0	0	37	455
Grapes	36	39	56	6	17	184	378	0	0	20	736
Total Crop Area	**323**	**65**	**572**	**313**	**2,139**	**2,005**	**3,127**	**161**	**61**	**749**	**9,515**
Multiple Crop	0	0	142	30	52	56	63	0	0	104	447
Irrigated Land Area	323	65	430	283	2,087	1,949	3,064	161	61	645	9,068

managers of cooperatives, and others. Three basic factors guided the CMO: current and future demand for food and fiber by the world's consumers; the share California could produce to meet this worldwide demand; and technical factors, such as crop yields, pasture carrying capacities, and livestock feed conversion ratios that affect demand for agricultural products. (Milk and dairy products are California's largest agricultural product, in terms of gross value. The demand for these products is reflected in the markets for alfalfa, grains, and other fodder used by dairies.) The CMO forecasts a statewide crop mix and estimates corresponding irrigated acreage. The major findings of the CMO for year 2020 were that grain and field crop acreage would decrease, while acreage of truck crops and permanent crops would increase.

The Central Valley Production Model is a mathematical programming model that simulates farming decisions by growers. Inputs include detailed information about production practices and costs as well as water availability and cost by source. The model also uses information on the relationship between production levels of individual crops and crop market prices. The model's geographic coverage is limited to the Central Valley, which represents about 80 percent of the State's irrigated agricultural acreage. The CVPM results also indicated future crop shifting, from grains and field crops to vegetables, trees, and vines. The CVPM forecast showed a small reduction in crop acreage from 1995 to 2020.

One factor not included in Bulletin 160-98 irrigated acreage forecasts is the potential large-scale conversion of agricultural land to wildlife habitat for reasons other than westside San Joaquin Valley problems. The CALFED program represents the largest pending example of potential conversion of irrigated agricultural lands to habitat, as described in CALFED's March 1998 first draft programmatic EIR/EIS and supporting documents. CALFED's potential land conversion amounts have not been included in the Bulletin 160-98 irrigated acreage forecast because they are preliminary at this time (a site-specific environmental document with an implementation schedule for land conversion has not yet been prepared), and because CALFED's preliminary numbers are so large relative to the Bulletin's market-based forecast of irrigated acreage that they would negate the results of the forecast. Overall, CALFED program activities as presently planned could convert up to 290,000 irrigated acres to habitat and other uses, an amount almost as great as the 325,000-acre reduction in irrigated acreage forecast in the Bulletin. Water use implications of large-scale land conversions are not included in the Bulletin 160-98 forecast. Impacts of such land conversions are expected to be addressed in the next water plan update, when CALFED's program may be better defined.



There is a perception that only drip irrigation is an efficient agricultural water use technology. High efficiencies are possible with a variety of irrigation techniques. Considerations such as soil type, field configuration, and crop type influence the choice of irrigation technique.

The difficulty in estimating impacts from large-scale land conversion programs stems from the domino effect that changes in acreage in one location have on acreage and crop types in other areas, and how crop markets determine which crop shifts are feasible. For example, CALFED's preliminary reports suggest that up to 190,000 irrigated acres in the Delta could be converted to other land uses. This amount represents about 40 percent of Delta irrigated acreage, whose principal crops are corn, alfalfa, tomatoes, grain, orchard crops, and truck crops (e.g., asparagus). Some land conversion in the Delta might result in production on new agricultural lands—most likely, rolling hills on the edge of the valley floor which are only suitable for limited crop types (orchards and vineyards). Some of the land conversion might result in increased demand in other areas for the affected crops, such as increased demand for asparagus from the Imperial and Salinas Valleys.

Table ES4-5 shows the 2020 irrigated acreage fore-

TABLE ES4-5

California Crop and Irrigated Acreage by Hydrologic Region, 2020 Level
(thousands of acres)

Irrigated Crop	***NC***	***SF***	***CC***	***SC***	***SR***	***SJ***	***TL***	***NL***	***SL***	***CR***	***Total***
Grain	66	1	21	5	249	152	201	8	0	97	800
Rice	0	0	0	0	484	15	0	1	0	0	500
Cotton	0	0	0	0	15	171	888	0	0	46	1,120
Sugar beets	6	0	2	0	52	18	13	0	0	29	120
Corn	2	0	3	2	90	188	101	1	0	3	390
Other field	3	1	14	1	154	139	110	0	0	33	455
Alfalfa	62	0	20	6	147	181	238	50	24	217	945
Pasture	123	5	16	6	316	165	26	103	18	32	810
Tomatoes	0	0	8	4	141	93	130	0	0	14	390
Other truck	28	11	373	43	79	197	300	2	1	231	1,265
Almond/pistachios	0	0	0	0	127	270	198	0	0	0	595
Other deciduous	7	6	20	3	234	153	199	0	2	1	625
Subtropical	0	0	18	117	33	10	215	0	0	32	425
Grapes	38	41	75	3	29	183	366	0	0	15	750
Total Crop Area	**335**	**65**	**570**	**190**	**2,150**	**1,935**	**2,985**	**165**	**45**	**750**	**9,190**
Multiple Crop	0	0	150	10	70	80	100	0	0	145	555
Irrigated Land Area	335	65	420	180	2,080	1,855	2,885	165	45	605	8,635

TABLE ES4-6

Applied Agricultural Water Use by Hydrologic Region (taf)

Region	*1995*		*2020*	
	Average	*Drought*	*Average*	*Drought*
North Coast	894	973	927	1,011
San Francisco Bay	98	108	98	108
Central Coast	1,192	1,279	1,127	1,223
South Coast	784	820	462	484
Sacramento River	8,065	9,054	7,939	8,822
San Joaquin River	7,027	7,244	6,450	6,719
Tulare Lake	10,736	10,026	10,123	9,532
North Lahontan	530	584	536	594
South Lahontan	332	332	257	257
Colorado River	4,118	4,118	3,583	3,583
Total (rounded)	**33,780**	**34,540**	**31,500**	**32,330**

cast. The total irrigated crop acreage is forecasted to decline by 325,000 acres from 1995 to 2020, primarily in the San Joaquin Valley and South Coast areas. Reductions in crop acreage are due to urban encroachment, drainage problems in the westside San Joaquin Valley, and a more competitive economic market for California agricultural products. Grain and field crops are forecasted to decline by about 631,000 acres. Truck crops and permanent crops are forecasted to increase by about 238,000 and 68,000 acres, respectively. Acreage with multiple cropping is forecasted to increase by 108,000 acres, reflecting the expected increased production of truck crops. These statewide findings are used in developing the base year and forecasted agricultural water demands.

Summary of Agricultural Water Use

Crop water use information and irrigated acreage data are combined to generate the 2020 agricultural water use by hydrologic region shown in Table ES4-6. As previously noted, the 2020 forecasted values take into account EWMP implementation, which results in a 2020 applied water reduction of about 800 taf.

Environmental Water Use

Bulletin 160-98 defines environmental water as the sum of:

- Dedicated flows in State and federal wild and scenic rivers
- Instream flow requirements established by water right permits, DFG agreements, court actions, or other administrative documents
- Bay-Delta outflows required by SWRCB
- Applied water demands of managed freshwater wildlife areas

This definition recognizes that certain quantities of water have been set aside or otherwise managed for environmental purposes, and that these quantities cannot be put to use for other purposes in the locations where the water has been reserved or otherwise managed. This definition also recognizes that these uses of environmental water can be quantified. Unlike urban and agricultural water use, much of this environmental water use is brought about by legislative or regulatory processes. Certainly the environment uses more water than is encompassed in this definition—the rainfall that sustains the forests of the Sierra Nevada and the North Coast, the winter runoff that supports flora and fauna in numerous small streams, the shallow groundwater that supports riparian vegetation in some ephemeral streams—but the Bulletin's definition captures uses of water that are managed (in one fashion or another) and quantifiable. As described earlier, average annual statewide precipitation over California's land surface amounts to about 200 maf. About 65 percent of this precipitation is consumed through evaporation and transpiration by the State's forests, grasslands, and other vegetation. The remaining 35 percent comprises the State's average annual runoff of about 71 maf. The environmental water demands discussed in this section are demands that would be met through a designated portion of that average annual runoff. As with urban and agricultural water use, environmental water use is shown on an applied water basis.

TABLE ES4-7

Wild and Scenic River Flows by Hydrologic Region (taf)

	1995		*2020*	
Region	***Average***	***Drought***	***Average***	***Drought***
North Coast	17,800	7,900	17,800	7,900
San Francisco Bay	0	0	0	0
Central Coast	98	28	98	28
South Coast	69	51	69	51
Sacramento River	1,733	736	1,733	736
San Joaquin River	1,974	939	1,974	939
Tulare Lake	1,614	751	1,614	751
North Lahontan	271	154	271	154
South Lahontan	0	0	0	0
Colorado River	0	0	0	0
Total (rounded)	**23,560**	**10,560**	**23,560**	**10,560**

Wild and Scenic River Flows

Flows in wild and scenic rivers constitute the largest environmental water use in the State. Figure ES4-2 is a map of California's State and federal wild and scenic rivers.

The 1968 National Wild and Scenic Rivers Act, codified to preserve the free-flowing characteristics of rivers having outstanding natural resources values, prohibited federal agencies from constructing, authorizing, or funding the construction of water resources projects having a direct or adverse effect on the values for which the river was designated. (This restriction also applies to rivers designated for potential addition to the national wild and scenic rivers system.) There are two methods for having a river segment added to the federal system—congressional legislation, or a state's petition to the Secretary of the Interior for federal designation of a river already protected under state statutes. No new federal designations have been made since publication of Bulletin 160-93.

A number of river systems within lands managed by federal agencies are being studied as candidates. For example, USFS draft environmental documentation in 1994 and 1996 recommended designation of five streams (129 river miles) in Tahoe National Forest and 160 river miles in Stanislaus National Forest. These waterways drain to the Central Valley where their flows are used for other purposes, and wild and scenic designation would not affect the existing downstream uses.

The California Wild and Scenic Rivers Act of 1972 prohibited construction of any dam, reservoir, diversion, or other water impoundment on a designated river. As shown on Figure ES4-2, some rivers are included in both federal and State systems. No new State designations have been made since Bulletin 160-93, although the Mill and Deer Creeks Protection Act of 1995 (Section 5093.70 of the Public Resources Code) gave portions of these streams special status similar to wild and scenic designation by restricting construction of dams, reservoirs, diversions, or other water impoundments.

Table ES4-7 shows the wild and scenic river flows used in Bulletin 160-98 water budgets by hydrologic region. The flows shown are based on the rivers' unimpaired flow. (The unimpaired flow in a river is the flow measured or calculated at some specific location that would be unaffected by stream diversions, storage, imports or exports, and return flows.) For the average year condition, the long-term unimpaired flow from the Department's Bulletin 1 was used. The estimated average unimpaired flow for the 1990-91 water years was used for the drought condition.

Instream Flows

Instream flow is the water maintained in a stream or river for instream beneficial uses such as fisheries, wildlife, aesthetics, recreation, and navigation. Instream flow is a major factor influencing the productivity and diversity of California's rivers and streams.

Instream flows may be established in a variety of ways—by agreements executed between DFG and a water agency, by terms and conditions in a water right permit from SWRCB, by terms and conditions in a FERC hydropower license, by a court order, or by an agreement among interested parties. Required flows on most rivers vary by month and year type, with wet year requirements generally being higher than dry year requirements. Converting from net water use analyses performed for prior editions of Bulletin 160 to the

FIGURE ES4-2.

California Wild and Scenic Rivers

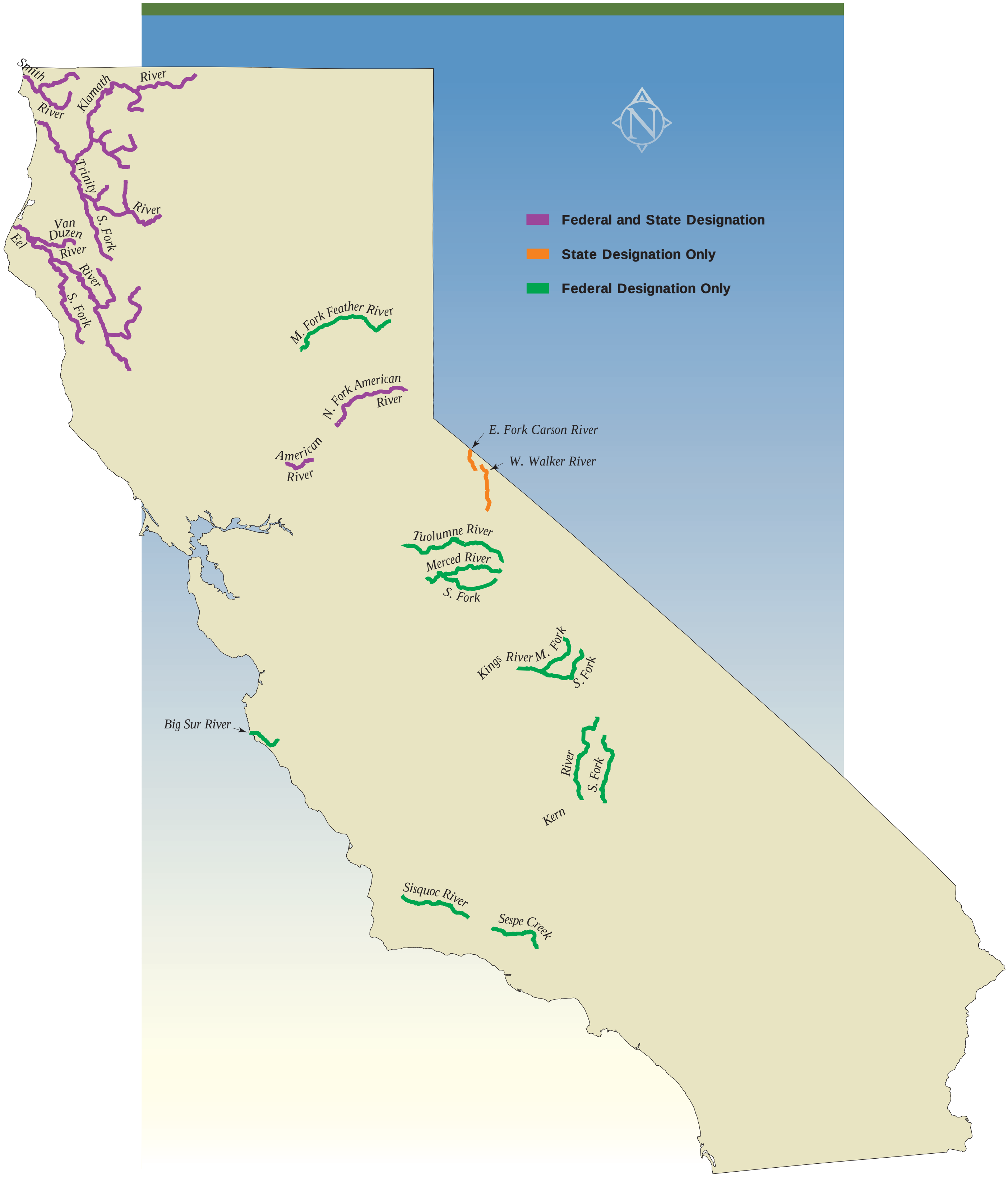


TABLE ES4-8

Instream Flow Requirements by Hydrologic Region (taf)

	1995		*2020*	
Region	***Average***	***Drought***	***Average***	***Drought***
North Coast	1,410	1,285	1,410	1,285
San Francisco Bay	17	9	17	9
Central Coast	20	9	20	9
South Coast	4	4	4	4
Sacramento River	3,397	2,784	3,397	2,784
San Joaquin River	1,169	712	1,169	712
Tulare Lake	0	0	0	0
North Lahontan	85	84	85	84
South Lahontan	107	81	107	81
Colorado River	0	0	0	0
Total (rounded)	**6,210**	**4,970**	**6,210**	**4,970**

applied water budgets used in Bulletin 160-98 created a challenge in properly accounting for multiple instream flows within a river basin. Bulletin 160-98 used a simplified approach in which only the largest downstream flow requirement was included in the water budgets. This simplified approach undercounts applied instream flow requirements on streams having multiple requirements. The Department is developing a new modeling approach for the next water plan update that will more accurately quantify applied instream flows.

Since the determination of 1990-level instream flow values used as base conditions in Bulletin 160-93, subsequent agreements or decisions have increased or added instream flow requirements for the Trinity River, Mokelumne River, Stanislaus River, Tuolumne River, Owens River, Putah Creek, and Mono Lake tributaries. In addition, ten new waterways have been added to the Bulletin 160-98 instream flow water budgets—the Mad River, Eel River, Russian River, Truckee River, East Walker River, Nacimiento River, San Joaquin River (at Vernalis), Walker Creek, Lagunitas Creek, and Piru Creek.

Table ES4-8 shows instream flows used in Bulletin 160-98 water budgets by hydrologic region. The drought year scenario shown in the tables represents the minimum annual required flow volume. For average water years, the annual required flow volume is computed by combining the expected number of years in each year type (wet, above normal, normal, below normal, and/or dry, as specified in existing agreements or orders).

Bay-Delta Outflow

Environmental water use for Bay-Delta outflow is computed by using operations studies to quantify SWRCB Order WR 95-6 requirements. Order WR 95-6 established numerical objectives for salinity, river flows, export limits, and Delta outflow. Operations studies were used to translate these numerical objectives into Delta outflow requirements for average and drought year scenarios. The studies computed outflow requirements of approximately 5.6 maf in average years and 4.0 maf in drought years.

Wetlands

The wetlands component of environmental water use is based on water use at freshwater managed wetlands, such as federal national wildlife refuges and State wildlife management areas. In general, wetlands can be divided into saltwater and brackish water marshes (usually located in coastal areas) and freshwater wetlands (generally located in inland areas).

Five areas of California contain the largest remaining wetlands acreage in the State—the Central Valley, Humboldt Bay, San Francisco Bay, Suisun Marsh, and Klamath Basin. The majority of the State's wetland protection and restoration efforts are occurring in these areas. Nontidal wetlands usually depend on a supplemental water supply, and protecting or restoring them may create demands for freshwater supplies.

Bulletin 160-98 quantifies applied water needs only for managed wetlands, because other wetlands types such as vernal pools or coastal wetlands use naturally-occurring water supply (precipitation or tidal action). Managed wetlands are defined for the Bulletin as impounded freshwater and nontidal brackish water wetlands. Managed wetlands may be State and federal wildlife areas or refuges, private wetland preserves owned by nonprofit organizations,

TABLE ES4-9

Wetlands Water Use by Hydrologic Region (taf)

	1995		2020	
Region	***Average***	***Drought***	***Average***	***Drought***
North Coast	325	325	325	325
San Francisco Bay	160	160	160	160
Central Coast	0	0	0	0
South Coast	27	27	31	31
Sacramento River	632	632	632	632
San Joaquin River	230	230	240	240
Tulare Lake	50	50	53	53
North Lahontan	18	18	18	18
South Lahontan	0	0	0	0
Colorado River	39	38	44	43
Total (rounded)	**1,480**	**1,480**	**1,500**	**1,500**

TABLE ES4-10

Applied Environmental Water Use by Hydrologic Region (taf)

	1995		2020	
Region	***Average***	***Drought***	***Average***	***Drought***
North Coast	19,544	9,518	19,545	9,518
San Francisco Bay	5,762	4,294	5,762	4,294
Central Coast	118	37	118	37
South Coast	100	82	104	86
Sacramento River	5,833	4,223	5,839	4,225
San Joaquin River	3,396	1,904	3,411	1,919
Tulare Lake	1,672	809	1,676	813
North Lahontan	374	256	374	256
South Lahontan	107	81	107	81
Colorado River	39	38	44	43
Total (rounded)	**36,940**	**21,240**	**36,980**	**21,270**

private duck clubs, or privately owned agricultural lands flooded for cultural practices such as rice straw decomposition. Some of the largest concentrations of privately owned wetlands are the duck clubs in the Suisun Marsh and the flooded rice fields in the Sacramento Valley. (Acreage of rice fields flooded to enhance decomposition of stubble remaining after harvest and to provide habitat for overwintering waterfowl was identified by Department land use surveys.) Table ES4-9 shows wetlands water demands by region.

Summary of Environmental Water Use

Table ES4-10 shows base 1995 and forecasted 2020 environmental water use by hydrologic region. The large values in the North Coast Region illustrate the magnitude of demands for wild and scenic rivers in comparison to other environmental water demands.

Water Use Summary by Hydrologic Region

Tables ES4-11 and ES4-12 summarize California's average and drought year applied water use by hydrologic region. The tables combine the urban, agricultural, and environmental water use described in this chapter. Also included are related minor uses such as conveyance losses and self-supplied industrial and powerplant cooling water. These demands, together with the water supply information presented in Chapter ES3, are used to prepare the statewide water balance shown in Chapter ES5 and the regional water balances shown in Appendix ES5A.

TABLE ES4-11

California Average Year Water Use by Hydrologic Region (taf)

Region	*1995*				*2020*			
	Urban	*Agricultural*	*Environmental*	*Total (rounded)*	*Urban*	*Agricultural*	*Environmental*	*Total (rounded)*
North Coast	169	894	19,544	20,610	201	927	19,544	20,670
San Francisco Bay	1,255	98	5,762	7,110	1,317	98	5,762	7,180
Central Coast	286	1,192	118	1,600	379	1,127	118	1,620
South Coast	4,340	784	100	5,220	5,519	462	104	6,080
Sacramento River	766	8,065	5,833	14,660	1,139	7,939	5,839	14,920
San Joaquin River	574	7,027	3,396	11,000	954	6,450	3,411	10,820
Tulare Lake	690	10,736	1,672	13,100	1,099	10,123	1,676	12,900
North Lahontan	39	530	374	940	50	536	374	960
South Lahontan	238	332	107	680	619	257	107	980
Colorado River	418	4,118	39	4,570	740	3,583	44	4,370
Total (rounded)	**8,770**	**33,780**	**36,940**	**79,490**	**12,020**	**31,500**	**36,980**	**80,500**

TABLE ES4-12

California Drought Year Water Use by Hydrologic Region (taf)

Region	*1995*				*2020*			
	Urban	*Agricultural*	*Environmental*	*Total (rounded)*	*Urban*	*Agricultural*	*Environmental*	*Total (rounded)*
North Coast	177	973	9,518	10,670	212	1,011	9,518	10,740
San Francisco Bay	1,358	108	4,294	5,760	1,428	108	4,294	5,830
Central Coast	294	1,279	37	1,610	391	1,223	37	1,650
South Coast	4,382	820	82	5,280	5,612	484	86	6,180
Sacramento River	830	9,054	4,223	14,110	1,236	8,822	4,225	14,280
San Joaquin River	583	7,244	1,904	9,730	970	6,719	1,919	9,610
Tulare Lake	690	10,026	809	11,530	1,099	9,532	813	11,440
North Lahontan	40	584	256	880	51	594	256	900
South Lahontan	238	332	81	650	619	257	81	960
Colorado River	418	4,118	38	4,570	740	3,583	43	4,370
Total (rounded)	**9,010**	**34,540**	**21,240**	**64,790**	**12,360**	**32,330**	**21,270**	**65,960**